SPECIFICATION AMENDMENTS

Please amend the Title of the application to read:

AN IMAGE PICKUP APPARATUS UTILIZING A PLURALITY OF CONVERGING LENSES

Please amend Pages 1, 10, 17, 19, and 22, as indicated on the following corresponding pages.

IMAGE PICKUP APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an image pickup apparatus with a plurality of pixels for converting converged light into electric signals.

Related Background Art

A conventional solid-state image pickup device has photoelectric conversion elements such as photodiodes for converting received light into electric signals and microlenses for converging light on photoelectric conversion elements, as described in, for example, Japanese Patent Application Laid-open No. 05-040201.

A microlens is provided for preventing the sensitivity of a photodiode from being lowered by the amount of light reduced because of a smaller size of a recent ultra fine pixel.

Fig. 1A is a plan view of a conventional solid-state image pickup device. Fig. 1B is a cross sectional view of each pixel of the solid-state image pickup device shown in Fig. 1A. In Figs. 1A and 1B, reference numeral 1 represents a pixel having a photodiode 5 formed in the surface layer of a silicon substrate (Si substrate) ~~7~~ 18. Reference numeral 2 represents a light shielding layer for shielding the area of the pixel 2 excepting the photodiode 5.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 4A is a plan view of a pixel group (image pickup area) of a solid-state image pickup device according to the first embodiment of the invention. Fig. 4B is a cross sectional view of pixels in the first, third and fifth columns of the pixel group shown in Fig. 4A. In Figs. 4A and 4B, reference numeral 1 represents a pixel having a photodiode or photoelectric conversion element 5 formed in the surface layer of a silicon substrate (Si substrate)~~7~~ 18. Reference numeral 2 represents a light shielding layer having a light shielding area for shielding the area of the pixel 1 excepting the photodiode 5. Reference numeral 3 represents an opening area formed through the light shielding layer 2 through which light is incident upon the photodiode 5. Reference numeral 4 represents a microlens for converging light on the photodiode 5. Reference numeral 6 represents a color filter layer of red, green, blue or the like.

Although only 5 × 5 pixels are shown in Fig. 4A for the purposes of simplicity, several hundred thousands to several millions pixels are disposed two-dimensionally.

As shown in Figs. 4A and 4B, in this embodiment, the pixel 1 disposed nearer to the peripheral area than the center of the pixel group has a center of gravity of the light reception area of the photodiode 5

On Page 17 of the Specification please substitute the following paragraph for the original paragraph at lines 5-21 thereof.

--In Figs. 10 to 12, reference numeral 1 represents a pixel, reference numeral 2 represents a light shielding layer (light shielding area) for shielding an area excepting the photoelectric conversion area (photodiode area) of each pixel, and reference numeral 3 represents an opening area formed through the light shielding area and guiding light. Reference numeral 4 represents a microlens for converging light, reference numeral ~~6~~ 18 represents a silicon (Si) substrate, reference numeral 7 represents a evened SiN passivation layer, and reference numeral ~~8~~ 19 represents a microlens planarizing layer made of organic material. Reference symbol 9a represents an R pixel area, reference symbol 9b represents a G pixel area, reference symbol 9c represents a G pixel area, reference symbol 9d represents a B pixel area, and reference numeral 15 represents a wiring layer. In Fig. 10, reference numerals 11 denote a horizontal shift registers, reference numerals 12 denote a vertical shift registers, reference numerals 13 denote a read-out circuits and reference numeral 14 denotes an output amplifier.--

less optical shading can be obtained as shown in Fig. 15.

Four pixel areas may use the same layout in order to reduce a design load. However, it is practically more preferable to use the layout taking a refractive index of each color into consideration, i.e., the layout with a shift amount changed with each pixel.

In this embodiment, the surface passivation layer 7 is evened by chemical mechanical polishing (CMP). Therefore, the evening layer ~~10~~ can be thinned to 0.2 μm or thinner although a conventional evening layer is about 2 μm. It is therefore possible to set a distance between the photoelectric conversion area (photodiode area) and microlens 4, to 2 to 3 μm, although a conventional element requires a distance of 4 to 5 μm.

Fig. 16 is an equivalent circuit diagram of one pixel area of the solid-state image pickup device of this embodiment. In Fig. 16, reference numeral 11 represents a horizontal shift register, reference numeral 12 represents a vertical shift register, reference numeral 13 represents a read-out circuit, and reference numeral 14 represents an output amplifier.

Generally, a CMP process is in many cases a standard process of CMOS processes. If the embodiment is applied to a CMOS sensor, standard processes are not required to be changed greatly. Therefore, the development time can be shortened considerably and the

image pickup apparatus such as a digital camera, a thin image pickup apparatus can be realized.

The solid-state image pickup devices described in the first to seventh embodiments include various types of elements such as a CMOS sensor, CCD, BASIS, SIT, CMD and AMI.

Pixels are not limited only to two-dimensional pixels but pixels disposed one-dimensionally may also be used.

An image pickup apparatus according to the eighth embodiment will be described with reference to Fig. 19, this image pickup apparatus using one of the solid-state image pickup devices of the first to seventh embodiments.

In Fig. 19, reference numeral 101 represents a barrier serving as a protector for a lens 102 and as a main switch. The lens 102 focusses an optical image of an object upon a solid-state image pickup device ~~4~~ 104. Reference numeral 103 represents an iris for changing the amount of light passed through the lens 102. The solid-state image pickup device 104 may be any element of the first to seventh embodiments and picks up the object image focussed by the lens 102 in the form of image signals. Reference numeral 105 represents an image pickup processing circuit having a variable gain amplifier for amplifying the image signal output from the solid-state image pickup device 104, a gain